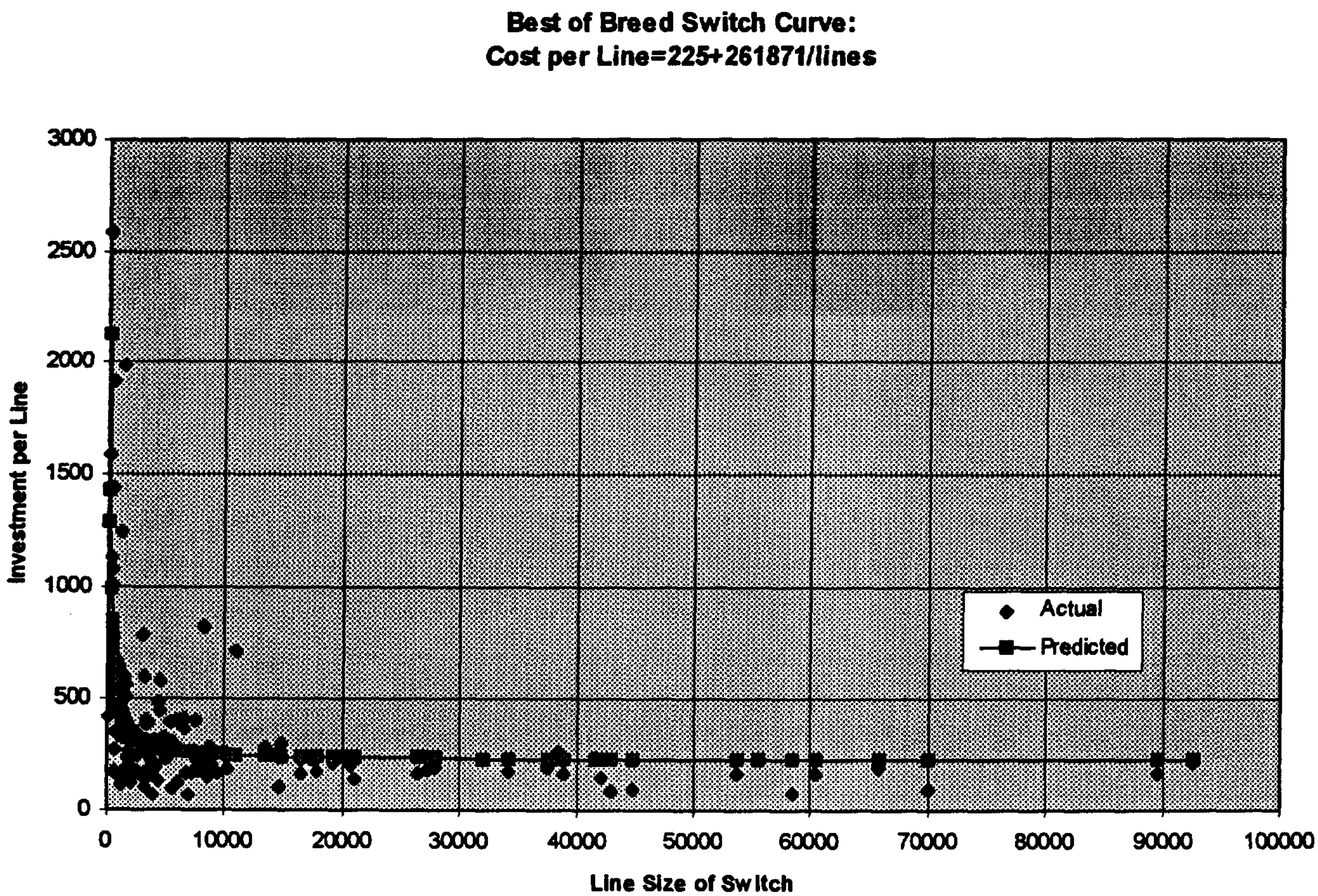
Appendix E

Best of Breed
Switch Sub-Group

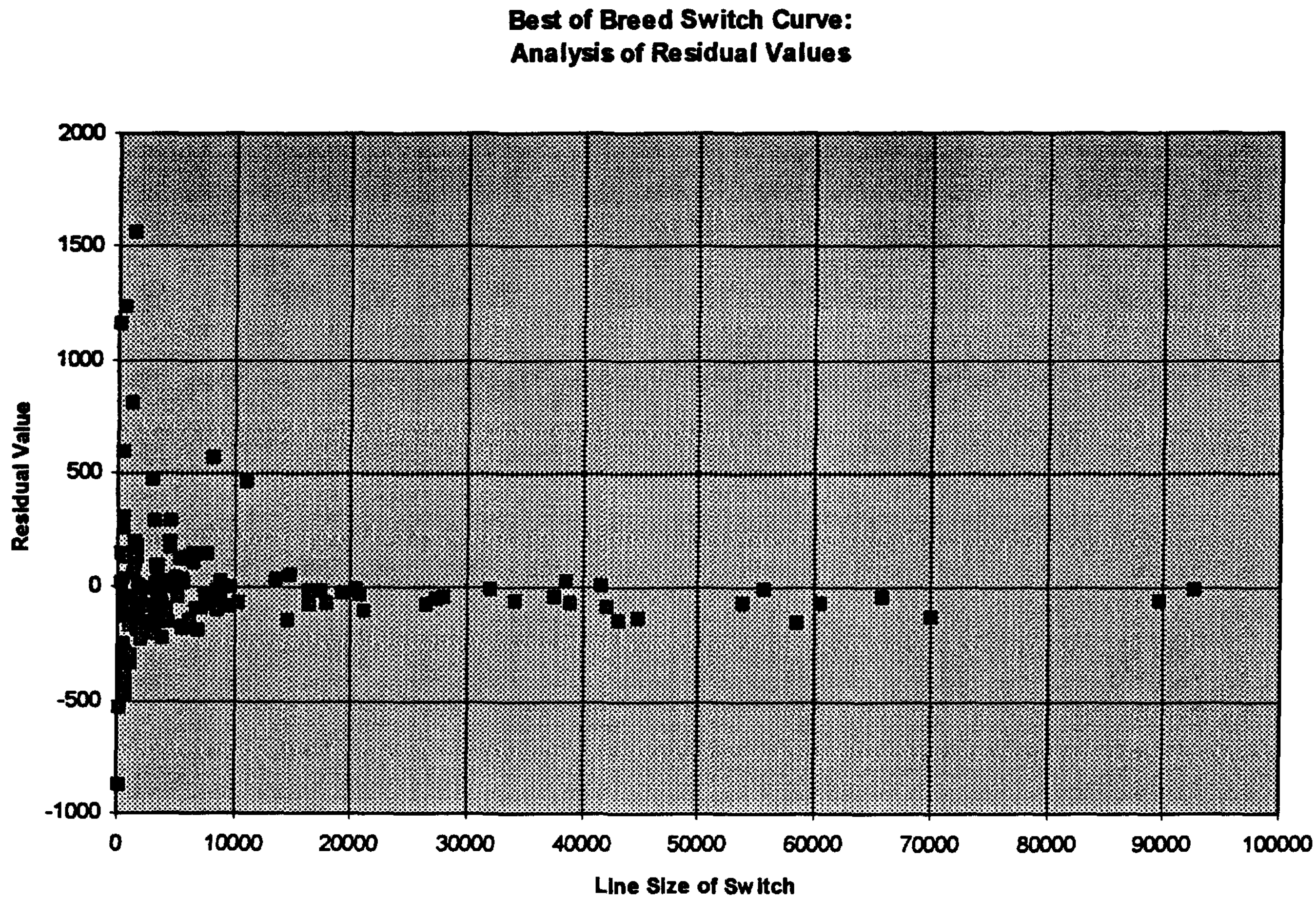
Switch Curve Development Report



Appendix F

Best of Breed
Switch Sub-Group

Switch Curve Development Report



FCC Data Request
Clli - ABLNTXORDS0

Copper Cable Lengths in Feet	
Cable Size	Cable Feet
4200	7717
3600	2150
3000	2169
2400	4737
2100	7401
1800	6984
1200	5063
900	29760
600	49295
400	22093
300	20073
200	40298
100	712616
50	750317
25	51757
18	0
12	3467

Fiber Cable Lengths in Feet	
Cable Size	Cable Feet
288	0
144	0
96	0
72	7170
60	9886
48	2782
36	7659
24	6880
18	1296
12	213002

Feeder Fill	73%
Distribution Fill	55%
Total Fill	62%

Benchmark Cost Proxy Model
Annual Charge Factors

Account Capital Cost (Annual Basis)

Account	Economic Life (years)	Return	Depreciation	Federal Income Taxes	State Income Taxes	Other Taxes
Land	0	0.1139	0.0000	0.0474	0.0063	0.0470
Motor Vehicle	8.19	0.0839	0.1052	0.0350	0.0047	0.0470
S.P. Vehicle	10.04	0.0858	0.0753	0.0358	0.0048	0.0470
Garage Work	12.1	0.0779	0.0798	0.0325	0.0043	0.0470
Other Work	13.81	0.0790	0.0716	0.0329	0.0044	0.0470
Building	42.61	0.0829	0.0250	0.0346	0.0046	0.0470
Furniture	16.09	0.0852	0.0597	0.0355	0.0047	0.0470
Office Support	11.08	0.0637	0.0925	0.0265	0.0035	0.0470
G.P. Computers	5.39	0.0699	0.1750	0.0291	0.0039	0.0470
Switching	9.8	0.0764	0.0984	0.0318	0.0042	0.0470
Circuit/DLC	8.46	0.0704	0.1181	0.0293	0.0039	0.0470
Pole	30.05	0.0820	0.0667	0.0342	0.0046	0.0470
Aerial Copper	12.49	0.0633	0.0941	0.0264	0.0035	0.0470
Aerial Fiber	18.92	0.0720	0.0654	0.0300	0.0040	0.0470
Underground Copper	11.37	0.0698	0.0872	0.0291	0.0039	0.0470
Underground Fiber	18.94	0.0797	0.0567	0.0332	0.0044	0.0470
Buried Copper	14.1	0.0692	0.0814	0.0288	0.0038	0.0470
Buried Fiber	18.94	0.0756	0.0582	0.0315	0.0042	0.0470
Conduit	50	0.1011	0.0213	0.0421	0.0056	0.0470

Benchmark Cost Proxy Model

Model Methodology

Presented by:
Pacific Bell, Sprint, and USWest

Benchmark Cost Proxy Model
Methodology

Background

During the Joint Board proceeding in CC Docket 96-45, Sprint and U S WEST sponsored the Benchmark Cost Model 2, and Pacific Telesis sponsored the Cost Proxy Model. Both of these models were excellent models which developed the overall cost of providing basic universal service. Although the two models approached the development of network costs from a totally different perspective, the bottom line results of the models came out surprisingly similar. As a result of this similarity, and in an effort to develop a consensus around a final proxy model for purposes of the targeted high cost fund scheduled to be implemented January 1, 1998, the three companies have combined their talents and energy to develop a superior model which incorporates the best aspects of both models. We call this model the Benchmark Cost Proxy Model (BCPM). (Over time this new model has also been referred to as the "Best of Both" or "Best of Breed", or more simply as "BOB" .)

The BCPM is a combination and improvement of the best attributes of both the BCM2 and the CPM. The BCM2 is well recognized for its dynamic building of the network. The CPM is heralded for its fine unit of geography (the "Grid"), its assignment of households to serving wire centers, and its flexible and dynamic reporting interface. The BCPM takes all of these attributes and adds some exciting new ones (expanded engineering inputs, capital cost module, etc..).

Highlights of the BCPM include:

* A new forward-looking capital cost model which allows the user to easily modify all factors relating to cost of capital and economic depreciation.
* Forward-looking investment and expense factors based upon data from a broad industry base reflecting the cost of procuring, installing and operating a state-of-the-art voice grade telecommunications network.
* All factors are easily user adjustable.
* Clear and concise documentation of all model equations and algorithms as well as complete documentation of the source of all default input variables.
* Greatly enhanced speed and ease of operation, including the ability the change program inputs either through easy to use drop-down menus or direct access to the EXCEL spreadsheets.
* The BCPM model provides methods to process multiple investment and expense views across multiple states. This provides the user with a great deal of flexibility in performing multiple scenario analysis.
* The BCPM allows the computation of forward-looking cost for unbundled network elements (available Phase 2).

The BCM2 used as its fundamental unit of study the census block group (CBG), while the CPM used the much smaller "grid cell". Incorporation of the grid cell data and/or the Census Block into the dynamic design process of the BCPM is scheduled for phase 2 of the release. In the current release, the BCPM is using CBG data.

Introduction

The ability to understand and make explicit the cost of Universal Service is crucial as telecommunication companies approach a critical junction in time. The secure world of highly regulated marketplaces has given way to impending competition. As competition becomes commonplace and regulation changes to allow greater marketplace flexibility, the current structure of funding Universal Service through a complex set of implicit cross subsidies is rapidly becoming obsolete. A new paradigm is needed to successfully fund Universal Service in the competitive environment. This new paradigm is compelled by the passage of the Telecommunications Act of 1996 and the Joint Board proceeding in CC Docket 96-45.

However, to properly set up this new Universal Service paradigm, the cost of basic telecommunication service needs to be determined for all customers. This cost should represent the cost of service that could be provided in the most efficient/cost effective manner. This cost would then be compared to the matching revenue (related to Universal service only) received or a benchmark rate to determine the amount of funding that is required for that customer. If this funding is calculated too low, it would unjustly harm serving LECs, discourage marketplace entry by CLEC's, and ultimately risk the provision of current and future technology too high cost customers. Conversely, if the fund is calculated to high, it would provide an unwarranted windfall to LECs and encourage inefficient market entry by CLECs.

However, it is not practical to determine the actual cost of every customer. Therefore, a method to approximate the actual costs of providing service in an economically sound manner while incorporating current and expected sound engineering practices had to be developed. The BCPM is such a tool.

The purpose of the BCPM is to estimate benchmark costs for providing business and residential basic local telephone service nationwide. Small geographic areas are examined because the cost of providing basic telephone service varies greatly even within the geographic unit of the wire center. The model can identify specific areas which are high cost to serve because of the physical characteristics of the area.

BCPM assumes all plant is placed at a single point in time. All facilities are created as if the entire country is a new service area. Therefore, the BCPM reflects the costs a telephone engineer faces installing new service to existing population centers.

BCPM is a geographically-based high level engineering model of a hypothetical local network. In phase 1, the geographic units used by the model are Census Block Groups (CBGs) designated by the U.S. Bureau of the Census. There are over 226,000 CBGs covering the entire U.S.[1] In phase 2, the BCPM will utilize a combination of CBGs and census blocks, a sub-unit of the CBG. The model utilizes a number of data elements for each of the geographic units it analyzes:

1) The geographic boundaries of the CBG as defined by the Census Bureau.

[1] BCPM is capable of using any small geographic unit. Phase 2 of BCPM will utilize a combination of Census Block Groups and Census Blocks to better locate customer locations within sparsely populated rural areas.

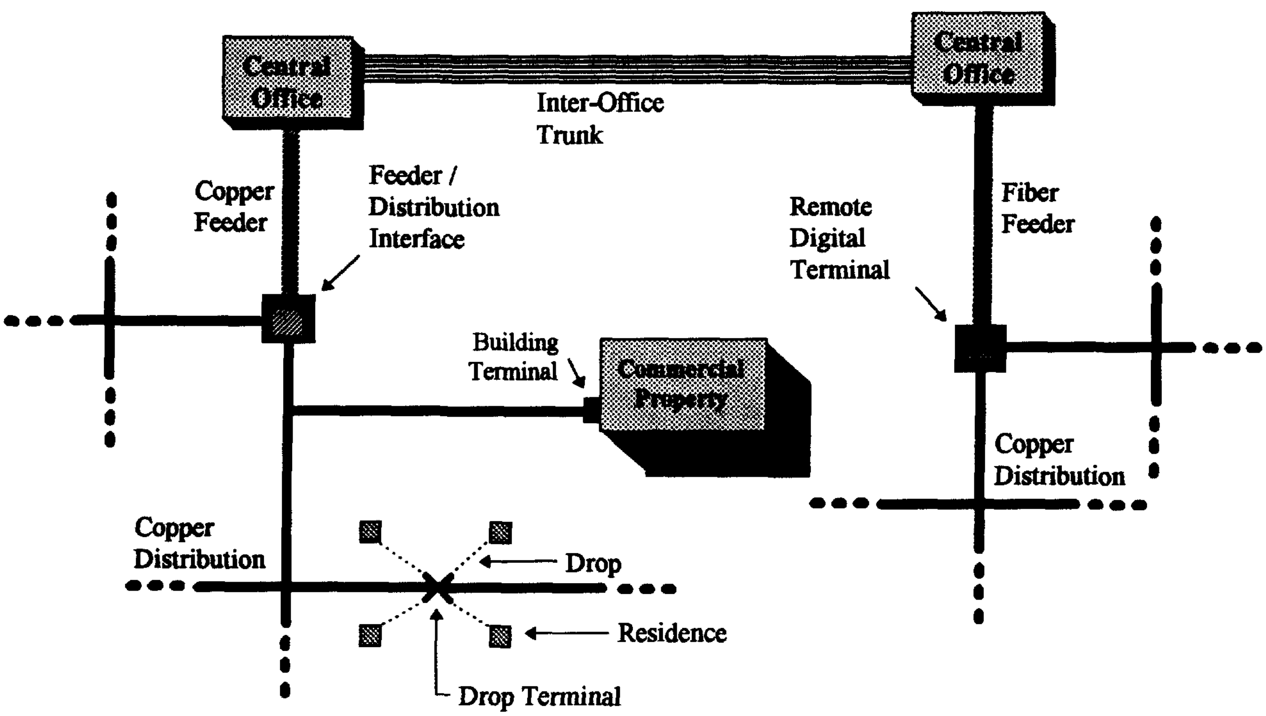
2) The geographic center (centroid) of the CBG.
3) The number of households in the CBG using the 1995 Census Bureau estimates. This data is used in conjunction with residential line counts by state from industry reports.
4) Terrain information from the U.S. Geologic Survey (U.S.G.S.) and Soil Conservation Service, which includes water table depth, depth to bedrock, hardness of the bedrock, surface soil texture, and slope.
5) Estimate of the number of business lines. This number is developed based on a Dunn and Bradstreet database of employees by CBG and industry reports of business lines by state.

The model starts with the existing central office locations and boundaries throughout the country, identified with Ontarget's Exchange Info data product. This data is input into a geographic information system where each CBG is associated with its serving central office based upon the location of the centroid of the CBG. Next, this information plus the relative physical locations and CBG information are input into the model. With this information BCPM designs a local exchange network utilizing a tree and branch topology.

Description of Local Exchange Network

The following figure depicts the elements of a typical local exchange network:

Typical Local Exchange Network



The public voice grade local exchange network is designed to provide an instantly available (under most circumstances) 3,500 Hertz telecommunications channel between any pair of users attached to the network. Components of the network are designed to meet minimum transmission characteristics for noise, echo return loss, envelope delay distortion, as well other quantifiable objectives for transmission quality. Many of these minimum transmission standards are met through basic engineering design criteria that specify the standard electrical and transmission characteristics for individual network components and groups of components. The following description traces a call on the public voice grade network from an originating customer premise through the network to terminate the call at a second customer premise.

Before a call can be initiated, a customer must have telephone set which is connected to the public voice grade network. The customer's telephone plugs into the wall to wiring also owned by the customer. The wiring in each residence and business premise is connected to the network through a telephone company owned interface device located at the customers premise. Single family housing units generally use a basic network interface device (a small gray box located on the outside of the house), while a large commercial building will have a building terminal designed to accommodate terminations for multiple customers. These interface devices connect the public voice grade telephone network to the customer-owned wiring and telephone sets.

Once the customer lifts the phone receiver call connection to the public telephone network begins. At the point the receiver is lifted a connection is made to the telephone company switch at the central office. This connection starts at the telephone set, through the inside wire, through the network interface device which connects to a drop wire. The drop wire consists of two or three pairs of copper wires which permanently connect the house to a drop terminal. In densely populated areas the drop wires from several residences will meet at a drop terminal. The drop terminal is where the drop wires are connected to a larger cable that connects many houses in a similar manner. This cable is called a distribution cable. The distribution cable then connects to a feeder/distribution interface, commonly called an FDI. The FDI connects many distribution cables to a feeder cable. The feeder cable goes to the central office location where it is connected to the telephone switch through a main distribution frame.

The connection to the switch is initiated by the customer lifting the phone receiver. The switch, which is really a large computer, acknowledges the customer action by providing dial tone to the customer, thereby notifying the customer that the switch is ready to receive the telephone number of the party where the call is to be completed. The customer enters the number by "dialing" through the telephone set. The switch interprets the tones or pulses into a terminating location on the network. The switch "looks up" the terminating location in a data base which tells the switch where to physically route the call. In this case the call is connected to a local inter-office trunk group that connects one central office location to another central office in the local calling area. Call traffic is consolidated and switched at telephone company central offices, which are connected with each other via high capacity trunks (usually optical fiber).

At the terminating switch, the terminating call number is translated to a customer location. The terminating switch generates a ringing signal to the terminating location. In this case, the signal follows a path in the switch to a digital channel of a fiber optic feeder route to a remote terminal. At the remote terminal the optical channel signal is converted into a digital electrical signal, and then converted to an analog electrical signal on the pair of copper wires that connects through a FDI, distribution cables, terminals, drop wire, and NID at the terminating location. The phone at the receiving location rings, at which point the receiving party my pick up its phone, completing the call.

BCPM Methodology

The BCPM methodology is presented in the following sections:

- *Assumptions for Loop Technology*
- Assumptions for Feeder Plant Architecture
- Assumptions for Distribution Plant Architecture
- Assumptions for Switch Technology
- Assumptions for Density
- Algorithms to Develop Basic Local Service Costs
- User Adjustable Inputs

Prior to addressing BCPM methodology a brief description of the incorporation of CPM characteristics and other major model changes from the BCM2 is provided.

Major Changes From BCM2 and CPM to BCPM

Based upon the work of the Best of Breed (BOB) industry group, public comments, technical analyses of the BCM2 and CPM, and comments made by the Joint Board, the best attributes of the CPM and BCM2 and other enhancements have been incorporated into the BCM2's base platform to more clearly present the actual engineering practices in the development of a local exchange network. BCPM includes *all* the costs of basic local telephone service and provides cost results by CBG, as well as higher geographic levels of aggregation.

BCPM differs from the BCM2 in two major areas. The first area of difference is that BCPM utilizes different inputs than the BCM2 and the second area of difference is that the structure of the model has been changed to provide more clarity to the user concerning the use of input areas and the purpose of calculations. Each of these areas is explained in more detail below.

Input Changes

The BOB industry group has provided the BCPM with an industry-wide composite of material, installation, and structure prices currently charged to a wide range of Local Exchange Carriers (LECs) for individual network components. This includes the prices for cables, digital loop carrier equipment, switches, feeder/distribution interfaces, manholes, poles, etc. This change allows the BCPM to use the widest possible base of data of equipment and installation prices currently paid by LECs. This aligns the BCPM with the Joint Board's Principle 1.

Additionally, the BOB group has provided an industry-wide composite of forward-looking operational and overhead expenses by account that are specifically associated with the provision of basic local exchange service. A new expense module allows these forward-looking operational expenses, which are stated on a per line basis, to be adjusted by the user by individual account. The BOB group also developed industry-wide forward-looking cost of capital and depreciation lives by account. These are used in the BCPM's new capital cost module and are fully user adjustable. This aligns the BCPM with the Joint Board's Principle 3 and Principle 4 which state that only forward-looking costs, including cost of capital and depreciation should be used in a proxy model. Additionally, this aligns the BCPM with the Joint Board's Principle 6 which provides for a reasonable allocation of joint and common cost for the supported service.

A final input area that is different from the BCM2 is the assignment of CBGs to wire center. Utilizing the CPM methodology, the BCPM utilizes an assignment of the CBG to the serving wire center, rather than the closest wire center. This assignment is based upon the location of the centroid of the CBG in relation to the wire center boundary obtained from Ontarget's Exchange Info. In Phase 2 of the BCPM, census blocks will be assigned to the serving wire center, providing even more precise network assignments of geographic areas. This aligns the BCPM with the Joint Board's Principle 1 which states that the proxy model will use the incumbent LEC's wire centers as the center of the loop network.

Model Structure

The BCPM provides a reorganization of elements of BCM2 and incorporates elements of CPM to provide a more user-friendly environment. This includes reorganizing inputs into functional categories, as well as creating separate modules for investment development, expense development, and capital cost development. Additionally, report generators are available that can provide detailed reports by CBG (or census block in Phase 2), wire center, company, or state.

The BCPM investment module develops investments for the feeder and distribution portions of the local loop and specifically identifies underground, buried, and aerial investments by metallic and non-metallic plant. Additionally the BCPM identifies the investments in conduit and pole accounts, so that each plant account can utilize its specific depreciation life in the development of depreciation expenses and capital costs. Other investment accounts are also individually quantified.

The BCPM provides an integrated module to develop structure costs for aerial, buried and underground installations by density group and terrain difficulty. This allows the user to individually vary cost of installation activities, such as plowing, as well as vary the percentage of a construction activity by density zone. Additionally, the user can vary the amount of an activity that can be shared between utilities, such as the placing of poles.

The BCPM provides new expense and capital cost modules that provide the user the ability to input USOAR account detail for operation and common expenses as well as giving the capability to adjust account specific depreciation lives, salvage values and cost of removal.

The BCPM organizes various plant characteristics by the seven density groups used in the CPM. This provides a better alignment of density-based network characteristics and costs.

All input sections are now more easily accessed by the user through drop-down menus. However, if the user wishes to access the input area as was available in BCM2, this option continues to exist.

Finally, the BCPM provides methods to process multiple investment and expense views across multiple states. This provides the user with a great deal of flexibility in performing multiple scenario analysis.

Model Methods

CBG Input Data

The CBG input data[2] for the BCPM was developed by Stopwatch Maps. An overview of the input data development is contained in Attachment A.

Assumptions for Loop Technology

Feeder cable (cable placed so that it can be supplemented at a later date) is deployed as analog copper plant where the total loop distance is less than the user-specified maximum copper cable length.[3] If the loop distance exceeds the maximum loop distance value, fiber feeder plant is deployed. Fiber feeder may extend into the CBG to maintain the maximum copper distribution cable distance set by the model user. The purpose of the maximum copper distribution constraint is to maintain the standard transmission and signaling characteristic of the loop network.

Distribution plant may contain analog copper technology when terminating signals at a voice grade level, or may utilize digital carrier when terminations are made at the DS1 signal level for a percentage of business lines.

BCPM uses two types of digital loop carrier (DLC) equipment depending on the number of lines needed at each remote terminal location. For line capacities greater than 240 lines, investments associated with large DLC systems are used. For capacities of 240 lines or less, investments associated with small DLC systems are used. The large DLC having a total capacity of 2,016 voice grade channels per four fibers and the small DLC having a total capacity of 672 voice grade channels per four fibers.

Assumptions for Feeder Plant Architecture

Feeder plant uses a tree and branch topology, with plant routes intersecting at right angles. Each feeder cable begins at the central office and ends at the feeder/distribution interface

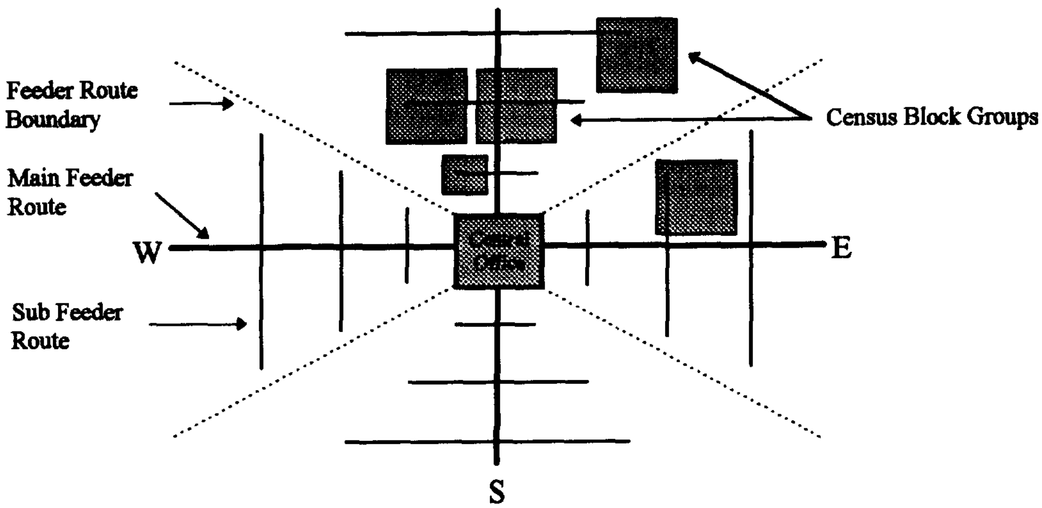
[2] The data included in the BCPM is the property of Stopwatch Maps Inc.. It is provided exclusively for use in the BCPM. All other uses are prohibited except by explicit agreement with Stopwatch Maps, Inc..

[3] The user may specify maximum copper distances of 9,000 feet, 12,000 feet, 15,000 feet, or 18,000 feet.

(FDI). Fiber feeder may extend into the CBG to ensure that the user specified maximum copper cable length is not exceeded, thus dividing the CBG into multiple distribution areas.

Four main feeder routes leave each central office[4]: directly East (quadrant 1); North (quadrant 2); West (quadrant 3) and South (quadrant 4). The feeder route boundaries are at 45 degree angles to the main feeder routes.

Feeder Plant Architecture



Both copper and fiber feeder cables share the structure and placement costs in the main feeder systems. As the main feeder routes move away from the central office and deploy cable capacity to the CBGs, the feeder cables taper in size to the capacity necessary for each individual segment.

Copper feeder cables range in size from 25 pair cable to 4,200 pair cable, while fiber feeder cable sizes range from 12 strand cable up to 288 strand cable. Feeder plant costs include: material cost of cable and electronics; capitalized cost of structure and placing the cable including manholes, conduit, and poles; electronics costs at the central office and remote; costs of in-line terminals, FDIs, splicing; and engineering.

<u>Assumptions for Distribution Plant Architecture</u>

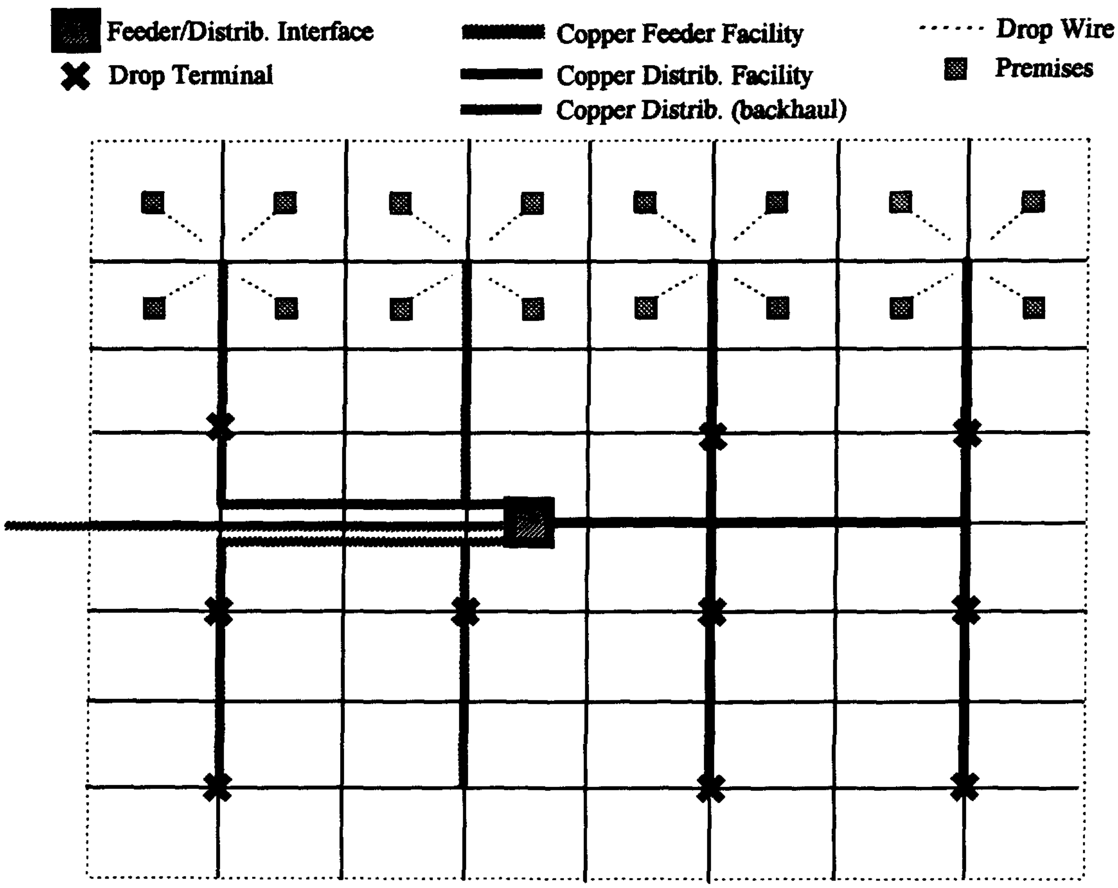
As with the BCM2, the BCPM assumes that all households within a CBG are uniformly distributed. In rural areas, the CBG area input data has been reduced reflecting the removal of areas that do not have road access.

Distribution cable begins at the distribution side of the FDI and continues to the customer premise. The distribution plant is designed to reach all households in the CBG through the placing of cables between subdivision lot lines. BCPM more precisely designs distribution plant for each CBG to ensure cables pass by each premise. The number of distribution cables may be as few as one for a small CBG to 20 or more cables in more densely

[4] A central office may have less than four feeder routes if no CBGs are located within a feeder quadrant.

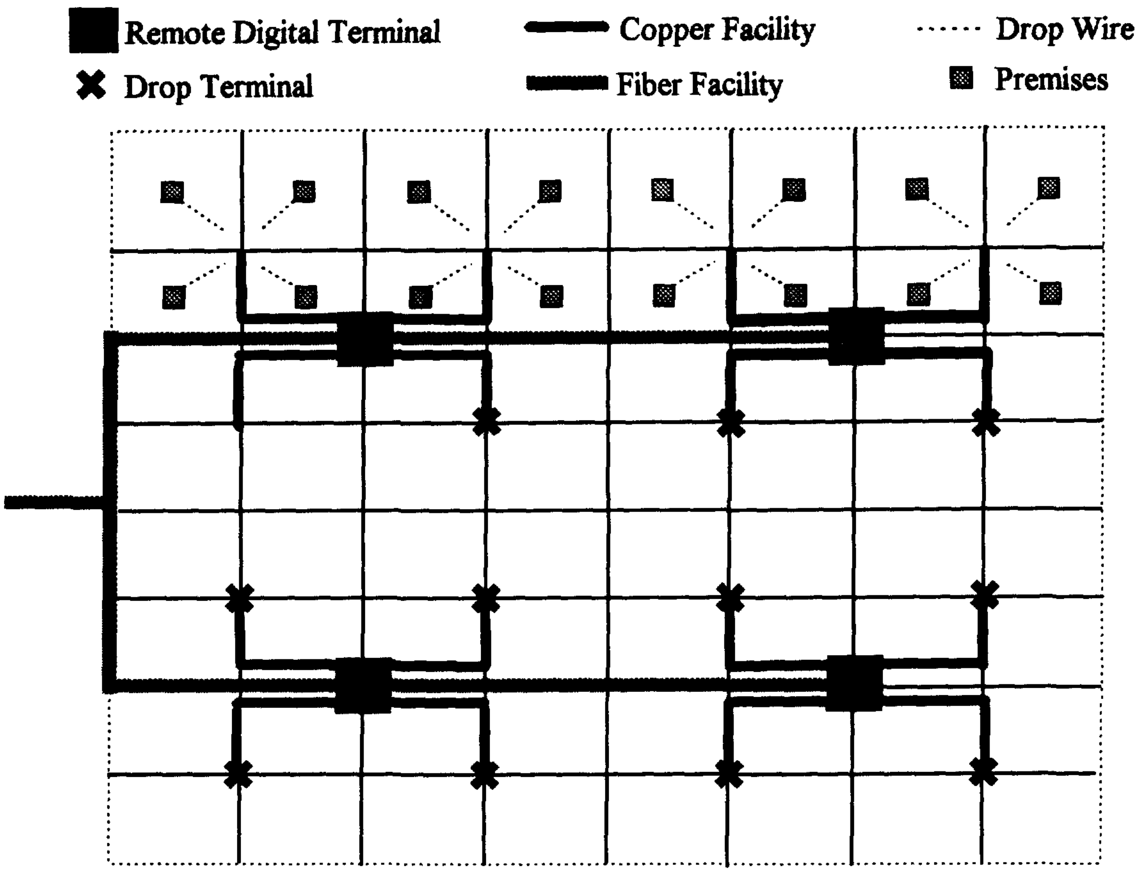
populated CBGs. An example of distribution plant with a copper feeder system is displayed below.

Example of Distribution Plant With Copper



In larger rural CBGs that are very sparsely populated, it may be necessary to extend the fiber feeder into the CBG itself to maintain copper cable lengths less than the user-specified maximum. An example of fiber feeder extending into the CBG is displayed in the next figure.

Example of Distribution Plant With Fiber



Investments for distribution plant include the material cost of the cable and its cost of installation and structure, as well as the network interface device, the drop wire, the drop terminal, splicing and engineering. Distribution cable sizes range from 25 pair cable to 3600 pair cable.

Since business lines are included by CBG, the BCPM distribution architecture uses fiber cable in very dense CBGs that require larger cable capacity than a maximum size copper distribution cable. Additionally, BCPM terminates a percentage of the lines in these dense CBGs at a digital DS-1 signal level, since a percentage of businesses have digital PBXs that utilize such capacity. (This is a user variable input).

Assumptions for Density

Density of existing development in a geographic area impacts three major aspects of the cost of providing basic telephone service. First, the density of existing development determines the construction methods that are used in deploying telephone plant. Second, the density of development determines the potential for growth and the future need for additional capacity. Finally, the density of development influences the mix of underground, buried, and aerial plant.

CBG densities are calculated in a three step process. First, the business lines are divided by a user input density adjustment. The default value for the density adjustment is 10 business lines occupying the physical space of one household unit. In the second step, the adjusted business lines are summed with the CBG households. Finally, this sum is divided by the square miles of the CBG. This insures that the proper density characteristics are assigned to the CBG.

Based upon the CPM, the BCPM uses seven different density groups to determine plant characteristics. These density classifications more closely match engineering breakpoints and, in addition, are almost equally spread on a logarithmic scale:

Density Groups (Households Plus Business Premises per square mile of CBG)

1.	0	to	10
2.	11	to	50
3.	51	to	150
4.	151	to	500
5.	501	to	2,000
6.	2,001	to	5,000
7.	5,000	and greater	

The density groups determine the mixture of aerial, buried, underground plant, feeder fill factors, distribution fill factors, and the mix of activities in placing plant and the cost per foot to place plant. These are all user adjustable inputs.

Terrain Assumptions

U.S.G.S. and Soil Conservation Service data for four terrain characteristics that impact the structure and placing cost of telephone plant are included as inputs to BCPM by CBG. These terrain variables include depth to water table, depth to bedrock, hardness of bedrock, and the surface soil texture. Combinations of these characteristics determine one of four placement cost levels:

Placement Cost Levels (increasing placement difficulty)

1. (Normal) Neither water table depth nor depth to bedrock is within placement depth for copper or fiber cable *and* surface soil texture does not interfere with plowing.
2. Either soft bedrock is within cable placement depth *or* surface soil texture interferes with plowing.
3. Hard bedrock is within cable placement depth.
4. Water table is within cable placement depth.

When both fiber cable and copper cable are placed together in an underground or buried installation, the fiber placement depth is used to determine the placement difficulty.

Assumptions for Switch Technology

The BCPM exclusively uses digital switching technology. However, no assumptions are made as to what type of switch is deployed (host, remote, or stand alone) or which manufacturer (e.g., Nortel, Lucent) produced the switch. Rather, the BCPM uses a composite cost curve derived from different size, types, and brands of generic digital switches for calculating switch investments. While each size switch has a unique fixed or start-up cost and a unique per line cost, the composite cost curve takes this into account through its derivation. The start-up cost includes central processor frames, billing and data recording equipment and frames, miscellaneous power equipment and back-up power, the main distribution frame, frames for testing, and basic software.

The data used in the model was based upon a Best of Breed data request to the LECs. This study requested that the LECs provide SCIS[5]-type output from model offices. These model offices were designed to only include the basic functionality necessary for the provisioning of basic local service.

Once the data was received, statistical modeling was performed to determine whether Company Size, Host/Remotes, and Company had a significant influence on the shape of the basic switch curve. Host/Remote was not a significant factor and therefore not used in the model. Company Size (Small, Medium, Large) was significant. However, due to the fact that only two midsize companies (the others were large) provided data, the proprietary nature of their data could not be protected[6]. Therefore, the factor was not used. Finally, Company was significant, as expected. This represents the fact that each company negotiates its' discounts, engineers to its' specifications, uses specific brands, etc. However, since all LECs did not provide data, this variable could not be used.

After excluding the aforementioned variables, a final switch curve is derived. The basic function of the switch curve is

Per line Investment = 225 + 261,871/Line size of the switch.

Algorithms to Develop Basic Local Service Costs

Feeder Plant Distance

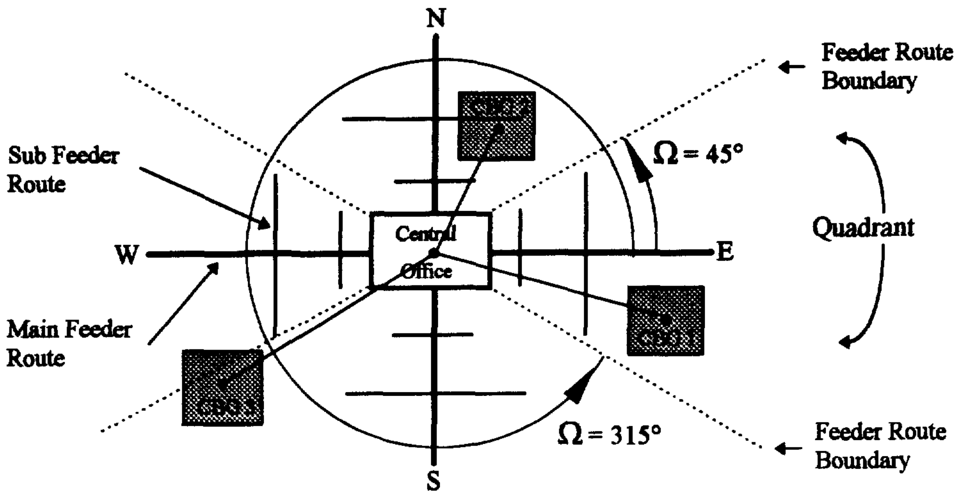
Typically, each LEC central office has four main feeder routes, radiating out from the central office (BCPM uses East, North, West, and South main feeder routes). Branching off from the main feeders are sub-feeders, typically at right angles to the main feeder, giving rise to the familiar tree and branch topology of feeder routes. Subscribers or homes are somewhat randomly spread within the route serving areas. The routes become less densely populated as the distance from the central office increases.

[5] SCIS is a Bellcore owned Switching cost model. This model has been widely accepted throughout the industry and by regulatory bodies as an accurate tool for measuring switching costs.

[6] It is anticipated that enough companies will respond so that a separate switch curve can be developed for each company size. This will allow the recognition that larger LECs may have greater buying power than smaller LECs.

The geographic centers (centroids) of the CBGs may fall in any of the four feeder route serving areas. In order to determine on which of the four main feeder routes (or quadrants) a CBG is served, an angle Ω is calculated. The angle Ω represents the counter-clockwise rotational angle between a line connecting the CBG with the closest central office and a line headed directly east from the central office. This is displayed in the following figure:

Determination of Feeder Quadrant



The relationship between the angle Ω and the feeder route is found in the table below:

East Feeder Route (Quadrant 1)	0° – 45° ; 315° – 360°	*CBG 1*
North Feeder Route (Quadrant 2)	45° – 135°	*CBG 2*
West Feeder Route (Quadrant 3)	135° – 225°	—
South Feeder Route (Quadrant 4)	225° – 315°	*CBG 3*

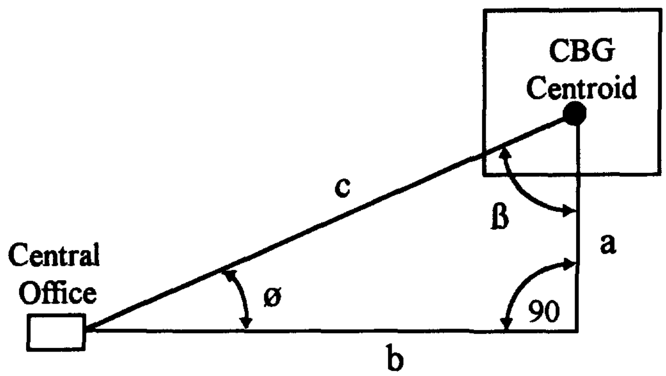
Feeder plant costs for a given CBG are estimated by approximating the length of the feeder cable from the serving central office to the FDI(s) serving the CBG. For simplicity it is assumed that each CBG is square in shape and that households within the CBG are distributed uniformly. In CBGs with less than 20 households per square mile the CBG area is reduced to eliminate non-populated areas.

Feeder plant consists of multiple segments. The first feeder segment leaving the central office travels along one of the four main feeder routes. The next segment of feeder plant (referred to as sub-feeder) leaves the main feeder route at a right angle and proceeds to the CBG. If the CBG is so large that copper distribution distances exceed the user-specified maximum length, as in the above Example of Distribution Plant with Fiber the feeder plant is extended into the CBG. In this example, more than one feeder leg is required within the CBG. In this case, the sub-feeder leg extending horizontally from the main feeder route splits vertically at the edge of the CBG at a right angle. This vertical sub-feeder segment is referred to as Part 1 sub-feeder. From this vertical sub-feeder, emanate two horizontal sub-feeder cables referred to as Part 2 sub-feeders. Each time additional sub-feeder cables are needed, the additional cable is sized to efficiently serve the demand along its portion of the route.

Calculating the feeder distance is a two-step process. First, the feeder plant distance to the CBG is calculated and second the feeder distance within the CBG is calculated.

The calculation of the feeder distance to the CBG starts with the airline distance between the serving central office and the centroid of the CBG. This is determined using the latitude and longitude of the serving central office and the latitude and longitude of the centroid of the CBG. Next, the airline distance is mathematically converted to an equivalent feeder plant route length.

Feeder Distance Calculation



Airline distance between Central Office and CBG Centroid = line c

Angle between Main Feeder Route (line b) and line c = Ø (determined from long./lat.)

Main Feeder Route Distance to CBG = line b = c * cos Ø

Sub-feeder route distance (line a) is calculated in a similar manner, however the sub-feeder does not extend into the CBG.

In cases where feeder plant is deployed within the CBG due to the considerations mentioned above, the Part 1 sub-feeder distance (d_{Part1}) is calculated as follows:

N_{LEG} = Number of Feeder-Type Legs
W_{CBG} = Width of CBG in feet

$$d_{Part1} = \left(\frac{N_{LEG}-1}{N_{LEG}}\right) * W_{CBG}$$

The Part 2 sub-feeder distance (d_{Part2}) is calculated as follows:

d_H = Longest Actual Horizontal Copper Distribution Distance
L_{LOT} = Length of Base Lot Side in feet

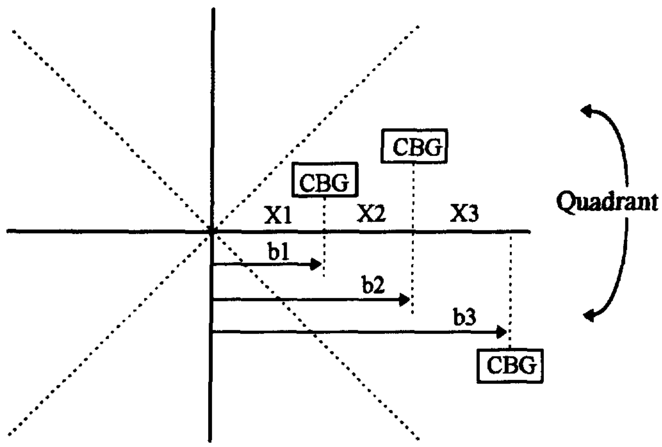
$$d_{Part2} = W_{CBG} - L_{LOT} - d_H$$

The preceding distance calculations may be increased if the minimum or maximum slope measurements for a CBG reach the trigger values. If the slope is greater than the trigger value, then the feeder and sub-feeder distance are increased by a user specified factor.

Shared Feeder Plant Distance

CBGs that are served along a common feeder route share feeder facilities. BCPM calculates the distances for the shared feeder segments by calculating the line b distance described above for each CBG in a quadrant. Once the line b distances are calculated, the model sorts the CBG data first by central office, then by quadrant, and finally by line b distance. An example of three CBGs in main feeder quadrant 1 is shown below.

Shared Feeder
Distance Calculation



In this example, there are three main feeder segments in quadrant 1: X1, X2, X3. The formula for calculating an individual feeder segment distance is:

For n (the number of CBGs within a quadrant) > 1,

Main feeder segment $X_n = b_n - b_{n-1}$

The total feeder distance for a CBG is the sum of main feeder distance and sub-feeder distances.

Cable Capacity and Material Investments for Shared Feeder Plant

The required capacity of a segment of copper feeder plant is determined by the sum of the lines of all CBGs utilizing that particular segment and copper technology. Next, the sum of these lines is divided by the fill factor for the density group associated with the segment. This calculation yields the copper cable capacity required for the segment. BCPM then "looks up" the cable capacity in a table to determine the actual cable size available (and its associated cost per foot) to meet the segment capacity. If the required capacity is greater than the size of the largest available cable, BCPM determines the number of maximum size cables and the next size cable to meet the capacity needs of the segment. The copper feeder cable sizes available in the model are 25, 50, 100, 200, 400, 600, 900, 1200, 1800, 2400, 3000, 3600, and 4200 pair.

The required capacity for a segment of fiber feeder plant is determined in a similar manner, however, large DLC technology and small DLC technology cannot share fiber strands because of differing transmission parameters. For large DLC systems, four fibers can carry up to 2,016 voice grade paths. If the segment capacity exceeds this limit, four additional fibers are required for each increment of 2,016 voice grade paths. For small DLC systems, four fibers can carry up to 672 voice grade paths. Like large DLC, each additional increment of 672 voice grade paths capacity requires an additional four fibers. The voice grade paths are determined by technology by summing the lines by CBG utilizing the particular technology and dividing the sum by the fill factor associated with the density group of the feeder segment.

The total capacity for a fiber feeder segment is the sum of the required large DLC fiber strands and required small DLC fiber strands. BCPM determines the number of maximum size fiber cables and the size of the additional fiber cable to meet the capacity needs of the segment. The fiber feeder cable sizes available in the model are 12, 18, 24, 36, 48, 60, 72, 96, 144, and 288 strands.

Once each feeder segment's cable size in feet and cost per foot is determined, a total material cost is calculated for the segment. Each CBG that utilizes the segment facilities shares the material cost on an equal cost per unit (per line).

Distribution Plant Distances

The CBG plant design is dependent upon the square mileage and the number of households served within the CBG.

The CBG is first checked to determine if the width of the CBG is greater than twice the maximum copper serving distance (specified by the user). If the width is greater, then the appropriate number of feeder-type legs will be extended into the CBG to sub-divide the area into multiple distribution areas. The vertical and horizontal copper distribution distances (d_V, d_H) from each FDI location are calculated as follows:

W_{CBG} = Width of CBG in feet
L_{LOT} = Length of Base Lot Side in feet
N_{LEG} = Number of Feeder-Type Legs
d_{HRC} = Number of Lots between Terminal Locations
N_{LOT} = Number of Lots Per Base Side

$$d_V = \frac{W_{CBG}}{N_{LEG}} \quad 2\,(L_{LOT}) \qquad\qquad d_H = C_{MAX} - .5\,(W_{CBG}) - L_{LOT}$$

IF $N_{LOT} = d_{HRC}$, THEN $d_H = .5 * (N_{LOT} - 1)$

OTHERWISE $d_H = (.5*(d_{HRC}) - 1) * L_{LOT}$

Cable Capacity and Material Investments for Distribution Plant

Copper cable and fiber cable capacities for distribution plant are determined in a similar manner as feeder plant. However, distribution plant only provides capacity to serve lines within the CBG. Thus, for distribution plant each of the horizontal plant legs serves an equal portion of the CBG line capacity as do the vertical legs. As with feeder plant the cable sizes (and their cost per foot) deployed by the model are determined by utilizing a "look up" table of the number of lines served by each cable leg (done separately for horizontal and vertical cables) divided by the fill factor for the CBG's specific density group.). The copper distribution cable sizes available in the model are 12, 25, 50,100, 200, 400, 600, 900, 1200, 1800, 2400, 3000, and 3600 pair.

The total distribution cable material investment is calculated as follows for both copper cable and fiber cable:

Distribution Cable Investment =

Number of Horizontal Distribution Legs * Horizontal Distribution Distance * Horizontal Cable Cost Per Foot + Number of Vertical Distribution Legs * Vertical Distribution Distance * Vertical Cable Cost Per Foot

Structure and Placement Costs

Structure and the cost of placing plant include the costs of poles, conduit, etc., and the capitalized costs of installing cable and wire facilities plant. BCPM uses a cost per foot for structure that varies by plant type, terrain, and density group. It represents the material and placing cost of structure. Each density group and terrain difficulty reflects a different mix of placing activities and structures. The structure calculations are integrated into the BCPM investment module. Following are examples of the inputs for underground, buried and aerial plant structure for the normal level of terrain difficulty associated with the 501 to 2,000 Households per Sq. Mi. density group.

Underground
Normal

Density Group 501-2000	Install	Feeder		Distribution	
Conduit Installation	Cost per Unit	% Activity	% Assigned Telephone	% Activity	% Assigned Telephone
Trench & Backfill	$ 2.69	27.00%	95.00%	40.00%	80.00%
Rocky Trench	$ 4.83	0.00%	95.00%	0.00%	80.00%
Backhoe Trench	$ 3.38	30.00%	95.00%	7.00%	80.00%
Hand Dig Trench	$ 6.00	6.00%	95.00%	6.00%	80.00%
Boring	$ 13.26	2.00%	95.00%	2.00%	80.00%
Cut & Restore Asphalt	$ 9.45	13.00%	95.00%	13.00%	80.00%
Cut & Restore Concrete	$ 10.30	12.00%	95.00%	12.00%	80.00%
Cut & Restore Sod	$ 4.41	10.00%	95.00%	20.00%	80.00%
		100%		100%	

	Buried Normal				
Density Group 501-2000	**Install**	**Feeder**		**Distribution**	
Buried Cable Installation	Cost	% of Activity	% Assigned Telephone	% of Activity	% Assigned Telephone
Plow	$ 1.22	15.00%	100.00%	20.00%	100.00%
Rocky Plow	$ 1.51	0.00%	100.00%	0.00%	100.00%
Trench & Backfill	$ 2.69	26.00%	95.00%	20.00%	80.00%
Rocky Trench	$ 4.83	0.00%	95.00%	0.00%	80.00%
Backhoe Trench	$ 3.38	11.00%	95.00%	2.00%	80.00%
Hand Dig Trench	$ 6.00	6.00%	95.00%	6.00%	80.00%
Bore Cable	$ 13.26	2.00%	95.00%	2.00%	80.00%
Push Pipe & Pull Cable	$ 7.98	5.00%	95.00%	5.00%	80.00%
Cut & Restore Asphalt	$ 9.45	13.00%	95.00%	13.00%	80.00%
Cut & Restore Concrete	$ 10.30	12.00%	95.00%	12.00%	80.00%
Cut & Restore Sod	$ 4.41	10.00%	95.00%	20.00%	80.00%
		100%		100 %	

		Aerial Normal			
Density Group 501-2000		**Feeder**		**Distribution**	
Aerial Cable Installation	Cost	Installation Cost per Unit	% Assigned Telephone	Installation Cost per Unit	% Assigned Telephone